82

Popular Computing

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On Artificial Intelligence...

PC82--2

A person that started in to carry a cat home by the tail was getting knowledge that was always going to be useful to him, and warn't ever going to grow dim or doubtful.

– Mark Twain

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BOOK REVIEW

This issue of POPULAR COMPUTING is largely devoted to what is ostensibly a review of a new book. However, as we have in the past (for example, issue 68, page 3), the review of the book is also a takeoff point for further thoughts on the subject covered in the book. The two topics should be kept distinct. To some extent, this treatment of a book constitutes a review of the book that the reviewer wishes had been written, which is a bit unfair.

Machines Who Think

A Personal Inquiry into the History and Prospects of Artificial Intelligence

by Pamela McCorduck

W. H. Freeman and Company, 1979, hard cover, 375 pages, $14.95.

It is now nearly a quarter of a century since the concept of artificial intelligence was articulated.*

The jacket blurb for this book begins "With a reporter's regard for facts...McCorduck traces the course of artificial intelligence from its mythic beginnings to its sometimes frightening future."

Well, no. Not with that title. If someone wants to sell a book on, say, women's liberation, with due regard for the facts, then a title like "Freeing the Slaves" would reveal a slight bias. McCorduck's title is cute, but the touted "reporter's regard for facts" has been attenuated before the book is opened.

**Actually, it is 22 years, which is indeed "nearly a quarter of a century," but the latter phrase sounds so much better.*

First, some quick background. The field known as Artificial Intelligence (AI) attempts to program computers to simulate, or mimic, or paraphrase whatever it is that human beings do when they are utilizing the space between their ears--what is called "thinking," or "creativity," or "originality"--we have lots of synonyms for it, which is usually the case for things we don't really understand.

When this sub-area of computing began, its devotees made all sorts of extravagant and impetuous claims, some of them ludicrous, and some simply wishful thinking--oops, there's that word again. The field attracted both governmental and industrial funding, and thus became a natural nesting place not only for brilliant and careful workers, but also for charlatans and some people who were excessively naive.

In the particular sub-areas for which money was made available (e.g., language translation) it became evident after some years that progress was somewhat slower than had been promised (it is irrelevant that those who made the promises were not the ones who were supposed to deliver the results). So some criticism broke out. The most prominent critics were Taube, Dreyfus, and Weizenbaum. Regardless of the source of the criticism, the generous funding ended, and serious work (except in "useless" areas like game-playing) slacked off.

However, the internecine war between the proponents and the critics of AI has never slackened, and this book seems to be carefully designed to keep it boiling. The author divides the AI field into the good guys (i.e., those who believe devoutly in AI) and the bad guys (i.e., those who criticize the good guys).

Time magazine has long used the technique of assigning favorable words to the good politicians (who are those that _Time_ favors at the moment), and unfavorable words to the bad politicians. Thus, those in _Time_'s good graces "respond," "murmur," "urge," and "smile." Those not in current favor "retort," "bellow," "cajole," and "grimace." It's a cheap trick, and highly effective. Much the same trick is used in this book. Ms. McCorduck evidently spent much time with the good guys, believing their every word, and dealt with the bad guys only in terms obtained from the good guys.

p. 256.	"But Robert Simmons, a good scientist..."	A fine example of oxymoron. One is a scientist, or one is not a scientist.
p. 248.	"Minsky's diction is as precise as a trained actor's, his knowledge nearly universal."	And he walks on water? Is the reasoning of someone with poor diction somehow suspect?
p. 251.	"...a restless young engineer named Joseph Weizenbaum..."	
p. 274	"He was a low-key redhead named Edward Feigenbaum..."	The repetitive use of "named" is a curious locution.
p. 275	"...with a young and somewhat eccentric South African scholar named Seymour Papert.."	
p. 258	"...Patrick Winston... now a professor himself..."	Professors are good. They always think good thoughts. This implied admiration does not seem to extend to Prof. Dreyfus or Prof. Weizenbaum.

A discipline that can't stand up to reasoned criticism is on shaky grounds. Anyone who wants to report on a whole field shouldn't dichotomize that field into the good guys and the bad guys. Above all, an objective reporter shouldn't let the good guys be the judge of their own work. When the neighbor's boy writes his "chess" program for daddy's Radio Shack computer, would you trust either the boy or his daddy for an objective opinion of that program? Would you go to the president of Standard Oil for an objective evaluation of the energy situation, oil-wise or profit-wise? Is it not perfectly proper to question the progress, or lack of it, that has been made in a field?

One of the basic problems involved in discussing AI is that the subject itself has a wide spectrum of activity and it is necessary to know, at every moment, just which part of the spectrum one is in. People just naturally tend to jump from one part to another, thus spoiling their train of logical thinking.

What is this spectrum? It might be delineated by the following set of questions:

1. What is the capital of the state of Oregon?

2. What is the 7.83 root of 2, correct to 30 significant digits?

3. What is the billionth prime number?

4. Are these the fingerprints of John Doe?

5. Are these the fingerprints of one of the persons in this file?

6. Whose fingerprints are these?

7. What move should I make next in this game?

8. Who first established the transcendental nature of the number pi?

9. Can I create a new melody?

10. Can I create a new melody in a specific musical genre?

11. Can I create a new melody that other people would regard as music?

12. What company ran the ad in last week's newspaper, on the same page as the Chevrolet ad?

13. Who was it who did the early AI work at IBM--his name starts with L?

14. Who was the author of the poem that includes the line "Upward, ever brighter, ever bright thy eyes"?

15. What is the Spanish equivalent of "Hunger is the best sauce"?

16. What is the English equivalent of the answer to question 15?

17. Is it possible to program a computer to do any of the tasks (1 to 16) above?

18. If it is possible, can humans create such programs?

"The cortex is also capable of abstractions as varied as the theory of relativity and the Song of Solomon. It can think about itself, and assign value judgments to what it thinks, such as that its thinking is wonderful. However, not every cortex is wonderful, and the theory of relativity and the Song of Solomon are not exactly representative samples of cortical achievement. I have heard that there are people who, given the question 'If you had two cows and lost one, how many would you have left?', cannot deal with it--not because the arithmetic is too difficult, but because they don't have two cows; they cannot entertain a hypothesis contrary to fact. If one could build a machine with power of abstract thought comparable to a typical human being--a mathematician, say--well, a typical mathematician, then--it would be worth doing. Of course artificial mathematicians might be a million times faster than the natural ones, in which case the total production of theorems, and other such goodies, staggers the imagination."

"I believe that man can develop extremely intelligent machines, and that he probably will, if he does not have some misadventure otherwise. This development, and his participation in it, will be his greatest adventure."

"It seems inescapable to me that the brain of man, like that of other vertebrates, is an item, of random design, to meet one basic purpose:survival. There is some doubt these days whether it will in fact meet this criterion, but there is no reason to suppose that it is well designed to perform intellectual man's proudest function: namely, to think. The fact that it has outthought things like saber-toothed tigers is no evidence that it is particularly apt for abstract thinking. It may be argued that I dismiss the survival-tested mechanism too quickly, and perhaps I do. The question arises when we ponder how to motivate advanced machines. I am confident we will discover means to do so, and I will be astonished if we are reduced to threatening them with tigers."

--John D. Williams

(The RAND Corporation, P-2170, December 29, 1960)

Taube, Mortimer, Computers and Common Sense; The Myth of Thinking Machines, Columbia University Press, 1961.

Dreyfus, Hubert, What Computers Can't Do; A Critique of Artificial Reason, Harper & Row, 1972.

Papert, Seymour, "The Artificial Intelligence of Hubert L. Dreyfus: A Budget of Fallacies," MIT AI Laboratory Memo 154.

Weizenbaum, Joseph, Computer Power and Human Reason, W. H. Freeman and Company, 1976.

Each of these questions might represent a step higher in the "thinking" continuum. The first questions could be relegated to a parrot, or a tape recorder. Number 2 would have been rated "meaningless" (or at best impossible) 300 years ago. We can handle it today, sort of, with a $40 pocket calculator, but as it is stated, it is a formidable problem, although methods of solution are clearly available. (The requirement for 30 significant digits takes it well out of the trivial class.)

The third question may never be solved, but it requires no great amount of thought to see that it is a mechanical question. The problem represented by the fourth question is now becoming solvable.

Starting with the fifth question, things begin to get sticky; that is, the questions begin to impinge on just what thinking _is_.

There are good things to say about the McCorduck book. It is well written, and it moves right along; the author is at home with words and ideas. She has done much homework in preparing for the book, and her presentation of the background and history of AI is unequalled. The people _in_ the AI field are nearly all academics who would die rather than write a straightforward English sentence, so that a translation of their theories and claims into readable English is a definite blessing. The book includes a wealth of background material and many anecdotes about the people in the field; indeed, it is not until page 92 that the author gets down to cases and begins to discuss her avowed subject.

Considering that all the workers in AI are, by definition, computer people, it is strange that some garbled information got through. On page 150, the IBM 604 is called a small computer, whereas even IBM called it a wired calculator. The IBM 702 did not come out in 1951; 1954 would be more like it. These technical lapses are infrequent, and minor.

There is a logical booby trap that I have labelled the Fulton non-sequitur. It goes like this:

1. They laughed at Fulton.

2. He turned out to be right.

3. They're laughing at me.

4. Therefore, I must be right.

Few people put it as bluntly as that, but it appears here (page 272) in a gentle form. When people make fun of something, it is possible that they mean to poke fun at it, because they find it funny, in the sense of peculiar. We do not usually record the instances of poking fun, in which it turns out that there was no serious side.

The main criticism of the book is that its presentation of the AI discipline has been cast entirely in terms of the people who are involved, rather than the concepts and ideas that have emerged, and on top of that, the people view seems to be decidedly one sided.

Arguments ad hominem do not contribute much to any discussion. Mortimer Taube attacked Oettinger; Dreyfus attacked Papert; Papert attacked Dreyfus; everybody attacked Weizenbaum; and I am criticizing McCorduck (as opposed to criticizing her arguments). Would it help the discussion, for example, if I had opened this review with "What do you expect from a book on this subject written by a woman novelist?" All of our verbiage is skirting the essential questions, which are "What is thinking?," and "Can machines be made to do it?"

The first of these two crucial questions is beyond answering, at least today. It stands alongside questions like "What is randomness?" and "What is Love?" and I doubt that anyone can come up with an answer that would satisfy even a dozen people at one time. It has got to be the slipperiest question ever devised. We seem to be left with just this: like the layman's view of art, we all believe that we know it when we see it.

But I reason that we can go one step beyond that. If we take the trouble to record now those activities that may some day be recognized as the milestones in the field, then we may some day be able to claim success. To date, this simple action has not been taken.

Thinking, as I have said, is a mighty slippery concept. We all know what it is; indeed, we must know what it is, as soon as we have created the word "thinking." (And, at this point, we are engaging in introspection--could that be the essential element of "thinking"?)

What progress has been made in AI in the last two decades? Very early in the game, the field segmented itself into small sub-goals, as if to say "if we can't get a machine to think broadly, maybe we can get one to think smaller thoughts." Let us examine each of those sub-fields for a progress report.

1. Game playing. This is the one big success of the AI field. Chess playing programs are at tournament level and improving rapidly; several self-contained chess machines are on the market; and rather good programs are available for personal computers. Fair programs exist for checkers and backgammon ("fair" in the sense that they will beat most people, but be beaten by experts). One game--Kalah--has been completely demolished (Digital Equipment's entry into the computing field was announced dramatically at one of the Eastern Joint Computer Conferences with a program for the PDP-1 that won consistently at Kalah). There is reason to believe that championship programs will soon be written for Gomoku and the various forms of Mancala. If the playing (to win) of open board games constitutes "thinking," then we are probably well on the way to having machines that think in this one area.

2. Music composition. This is an area of human endeavor that is restricted to a very select few. If it is a measure of man's ability to think, then the world has had few thinkers.

The AI advocates claim success in this sub-field, with programs that can produce any amount of music (usually of a specific type, such as chamber music) that cannot be distinguished, by experts, from music created in the old fashioned way.* The music so produced that I have heard sounds pretty bloody awful to me, but then so does 90% of what is played on the radio, so my judgement in this matter is of no value. I do believe that our collective knowledge of how music is constructed has been advanced by this work.

3. Theorem proving. The work of Newell, Shaw, and Simon (the Logic Theorist program) in proving theorems in the sentential calculus, and of Gelernter in proving theorems in plane geometry, is well known. All the work done in this area was undoubtedly brilliant and can be taken to be a simulation of human intelligence. Unfortunately, it seems to have led nowhere, and research in this sub-field has apparently disappeared.

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*See, for example, Music by Computers, by Foerster and Beauchamp, Wiley, 1969, with 4 plastic disks of audible output in the back of the book.

4. Information retrieval. As it turns out, the topic here is really indexing. If we can index things properly, then we can retrieve them, and conversely.

Take a simple case. We published the Bank Check problem some time back in this magazine, and an analysis of the problem some time later. In one of the three issues that referred to that problem, the complete solution was presented graphically. There are indeed three listings for "Bank Check" in our annual index--but which one of the three has that graphical solution? Since it was not properly indexed, one would have to look up all three issues to find it. [And, as we all know, in doing that, we are very likely going to find all sorts of other fascinating things that we meant to look up sometime. We have a word for that: serendipity. It's strictly a human trait--or is it?]

Or take another simple case. I wish to know the author and the name of the poem that contains the line:

"Nature's abundance, forever impressing,
endlessly repressing..."

Now, how do humans go about that sort of information retrieval? They ask the man who knows, say an English professor, who promptly gives the correct citation, probably with much additional information not asked for. We have no idea just how an English professor does this trick. We do know a way to program a computer to do it. Simply store every line of every published poem, sort and index those millions of lines, and use any standard table lookup technique. The obvious computing method (which would, in this case, come up empty, since I composed the line myself) is patently inefficient and far from feasible. The method used by humans is inexpensive and fast, and may involve thinking and intelligence. But we don't understand it.

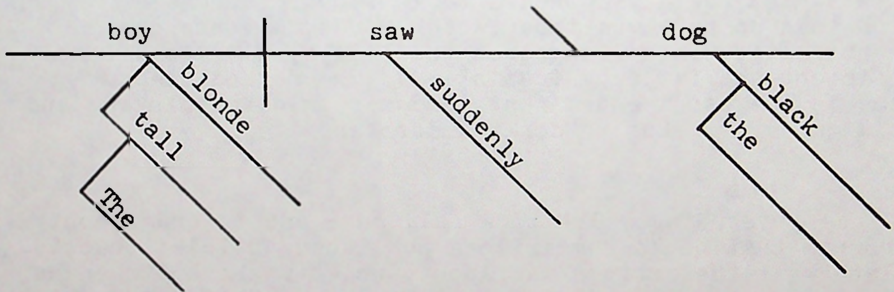
Many years ago, IBM took full page ads to brag about a program that would summarize a published article; that is, isolate what the article was about, which might be taken as a first step toward indexing an article. That program was never mentioned again. It seemed to work on some articles, but did not work on others.

The indexing problem is made vivid by glancing at any technical journal, where the "keywords" are given for each published article. The author of the article furnishes the words that he thinks the article should be indexed under, and the editors add all the other keywords that they can think of. These lists are getting longer and longer which means, I think, that we don't know how to index anything, much less how to write a computer program to do it.

5. Natural language translation. Here's the good one! For one thing, it is an activity that millions of humans can perform; thus, it is in a different class from composing symphonies or winning at chess. It is patently useful to a significant portion of the populace. And, since there is no upper bound on the amount of material published in every language, there would be a huge market for a program that could translate from natural language A into natural language B...

...and back. That's the way human translators function. I have, for example, a Japanese edition of one of my books, and I can't read even one ideograph in it. But someone who is fluent in both Japanese and English can read that edition and give it back to me in English, and it comes back very nearly as I wrote it. That is language translation in its human form, and is the form that must be imitated in order to claim intelligence on the part of a computer program. After two decades of research, and the expenditure of many millions of dollars, we have yet to see the first random idiomatic sentence so translated by machine. The best that has emerged so far might be called computer-aided translation, to be charitable about it. It thus becomes tempting to consider that perhaps we are not going to see it.

Along the way, when the language translation people found that the task was bigger than they had first imagined, they backed off to find simpler tasks that might be solved. One such task was machine analysis of sentence structure--what used to be taught as the diagramming of sentences in high school English classes:



...but the result was another debacle; that is, they couldn't produce such a program. It is again one of those peculiar things: diagramming worked only on the sentences in the book, not on sentences taken from the daily paper. Among other things, in order to be able to diagram a sentence, you have to be able to determine the part of speech of every word. As it turns out, we can't do that, either. Despite what the dictionary may say, the part of speech of a given word depends on its context. Or, as some wag put it, "any word can be verbed."

6. <u>Pattern recognition</u>. This appears to be the only "thinking" activity that is common to all humans. We all recognize faces, and thus isolate a few dozen cases out of billions. The possible variations on the human face do not appear to allow for that much discrimination (and we have all had the experience of confusing a total stranger with Uncle Henry in the airport), so the problem of recognizing a face must be an exacting one.

Consider how much further one can go in pattern recognition, though. I enter a shopping mall, and inquire at the information booth for a watch repair store, and I am told "Take the second corridor on your left; you can't miss it." As it turns out, the store I am seeking <u>does</u> have a sign in its window:

I wasn't told how far down the corridor it was, or which side of the corridor; the sign uses an obscure type face, is upside down, and is misspelled--but I can find it readily. Do you suppose we will ever be able to write a program to duplicate such human behavior? Does it take intelligence to find that sign? When I find the sign--while not even consciously looking for it--am I thinking?

We urgently need something more than the people <u>in</u> the field claiming that their work is successful, followed by others saying "You guys aren't doing too well." We need some milestones--some events, selected in advance, that will signal real progress. One possible milestone was just given; namely, the production of a program that can find signs with the same efficiency (or better!) as that presently exhibited by most humans.

We need to examine carefully what it is that large numbers of humans do when they are thinking (or when they think they are thinking, which is a different matter altogether). Most people would claim to be thinking when they are playing an open-board game like checkers. If they are serious about their game playing, they are doing <u>something</u> that excites their brain cells. If that something is thinking, and programs can be written to emulate such behavior, then perhaps we can chalk up a success for AI.

Let me see if I can list some possible milestones which, if we ever reach and pass them, will allow us to register further progress.

1. Championship programs for non-trivial games of strategy. This includes chess, checkers, Pasta (described in our issue number 12), Gomoku, Oware (described in our issue number 55), and games with a random element such as bridge, poker, and cribbage.

2. Even better, programs to devise and create new games for us.

3. Pattern recognition programs of all kinds. For example, match this fingerprint with one in the file, or establish that there is no match. Authenticate this check's endorsement. Verify that the person seeking entry is who he says he is, and that he is authorized to enter. Certify this piece of paper as non-counterfeit money. Verify that the voice on the telephone belongs to one of the 10,000 people whose voices are on file.

4. Prepare a 200-word abstract of this 10-page article.

5. Prepare a list of the 10 best keywords to index this 10-page article.

6. Translate this English chemistry article into idiomatic Spanish and translate the result back into idiomatic English (that's two separate programs) for checking.

7. For the following empirical data, determine the most likely curve to fit each section, fit those curves by least squares, and join the sections with third degree splines.

We must somehow define "thinking" as some process that men can do (most men, that is; we can exclude the extremes at both ends of the IQ scale) and that cats can't do. Simply demanding "reasoning" or "creativity" is not enough. In certain situations involving large dogs, my cat can reason much faster than I can, and arrive at the correct result--namely, her survival--with relative ease. Moreover, in uncovering new situations in which to endanger her health and safety, she exhibits amazing creativity and originality.

We must be careful about "originality." Ashby has pointed out that a good random number generator can produce for you unlimited original stuff, but sifting any sense out near-infinite amounts of nonsense is quite a trick.

The cat is quite good at pattern recognition (of faces, engine noises, and other cats). She soon learns to ignore those things that do not concern or amuse her. And, when there is nothing on the agenda, she quite sensibly takes a nap. I have stated all this with some hyperbole, but the point is serious; namely, that there must be activities that I can engage in that constitute a higher level of "thinking" than those exercised by my cat.

All such activities, it seems to me, reduce to some form of decision making. It is extraordinary, but we have not yet found a decision that is so low-level and simple that we know how it is made. We all make decisions--hundreds of them--every day, but the *how* of decision making eludes us. How do you decide which shoe to put on first? Always the left one? How did you first make *that* decision? Always the nearest one? What if they are equidistant from you? Too trivial a decision? Then find one that you regard as non-trivial, and describe how you make that one.

There are those who fear the possibility that there may some day be simulated human intelligence. Partly, this is fear of the unknown; partly, it is the "2001"-type fear that we wouldn't be able to pull the plug. Perhaps part of it is the threat that it poses to our egos. Thus, for example, if a computer program becomes the world's champion chess player, it may turn out that no man has ever played chess well; some people may find this idea terrifying.

I think we should look on the bright side: if we can create any sort of artificial intelligence, then *it* can create more, and we will snowball upward. Then the new intelligence can be put to work solving problems, starting with ones similar to those on page 6, and ultimately dealing with questions of war, poverty, and ignorance.

What we *don't* know about intelligence or thinking would fill a book. Unfortunately, McCorduck's book is not it.

Fred Gruenberger

(1.09256106824...)

The 32-Year Booboo

When sequenced calculating devices first appeared, shortly after World War II, one of the first problems put on nearly every machine was the calculation of a table of prime numbers, using the sifting scheme shown in Figure K. Indeed, we repeated essentially the same logic in our article in issue number 80. The scheme is quite inefficient, but it is simple (very easy to debug and test) and requires little storage.

The reasoning at Reference 5 is this: if N is initialized to an odd value, then incrementing N by 2 will maintain its parity; that is, we will by-pass all even values of N by adding 2 to N. By much the same reasoning, we could also by-pass all multiples of 3 by adding according to the pattern 2, 4, 2, 4, 2, 4, 2, 4,... Thus, if we start at N = 101, for example, we will examine only values of N like 103, 107, 109, 113, 115, 119, 121, 125,...

As far as N is concerned, the use of this trick is a toss-up. It does indeed by-pass all multiples of 3, but they would be eliminated in one division anyway. To by-pass them costs the extra programming and execution time of a switch; it hardly seems worthwhile. There's another angle, too: you either have to make sure to start the program with an N value of the form 6K+5 (with the switch initialized to add 2 first), or else have the program examine N and initialize the switch, which means more instructions to write, debug, and test. On the whole, it isn't worth it.

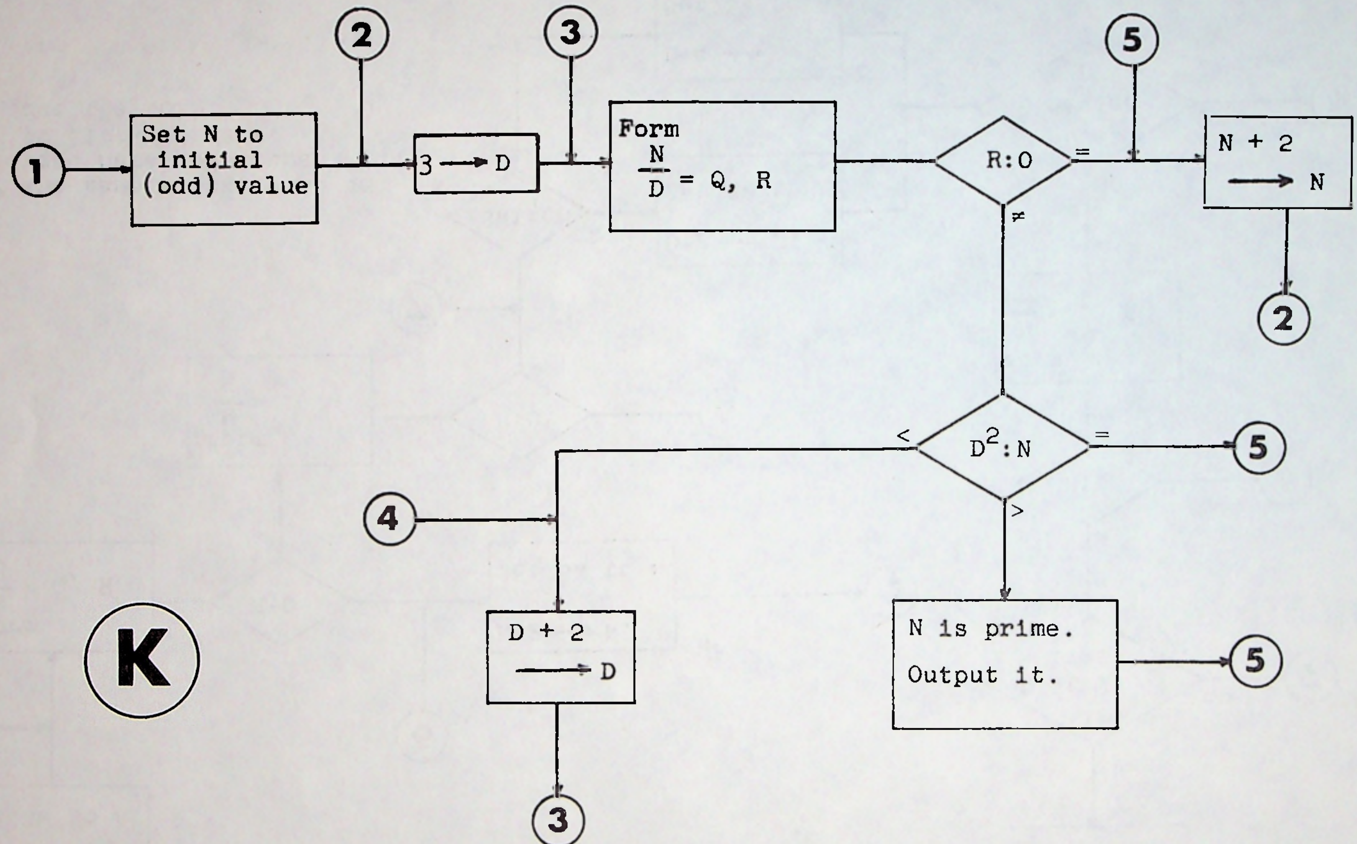
But, as Herman P. Robinson gently pointed out, all of the above reasoning applies also to Reference 4. Only now, we can by-pass all multiples of 3 in the generation of the divisors, and the resultant saving is well worth it. Just that simple change nearly doubles the speed of the program. In the article in issue 80, we were discussing calculating a table of primes in the one billion range. For each prime found, there would be nearly 16,000 add divisors less than the square root of the prime, and by by-passing those that are multiples of 3, some 5300 divisions could be eliminated.

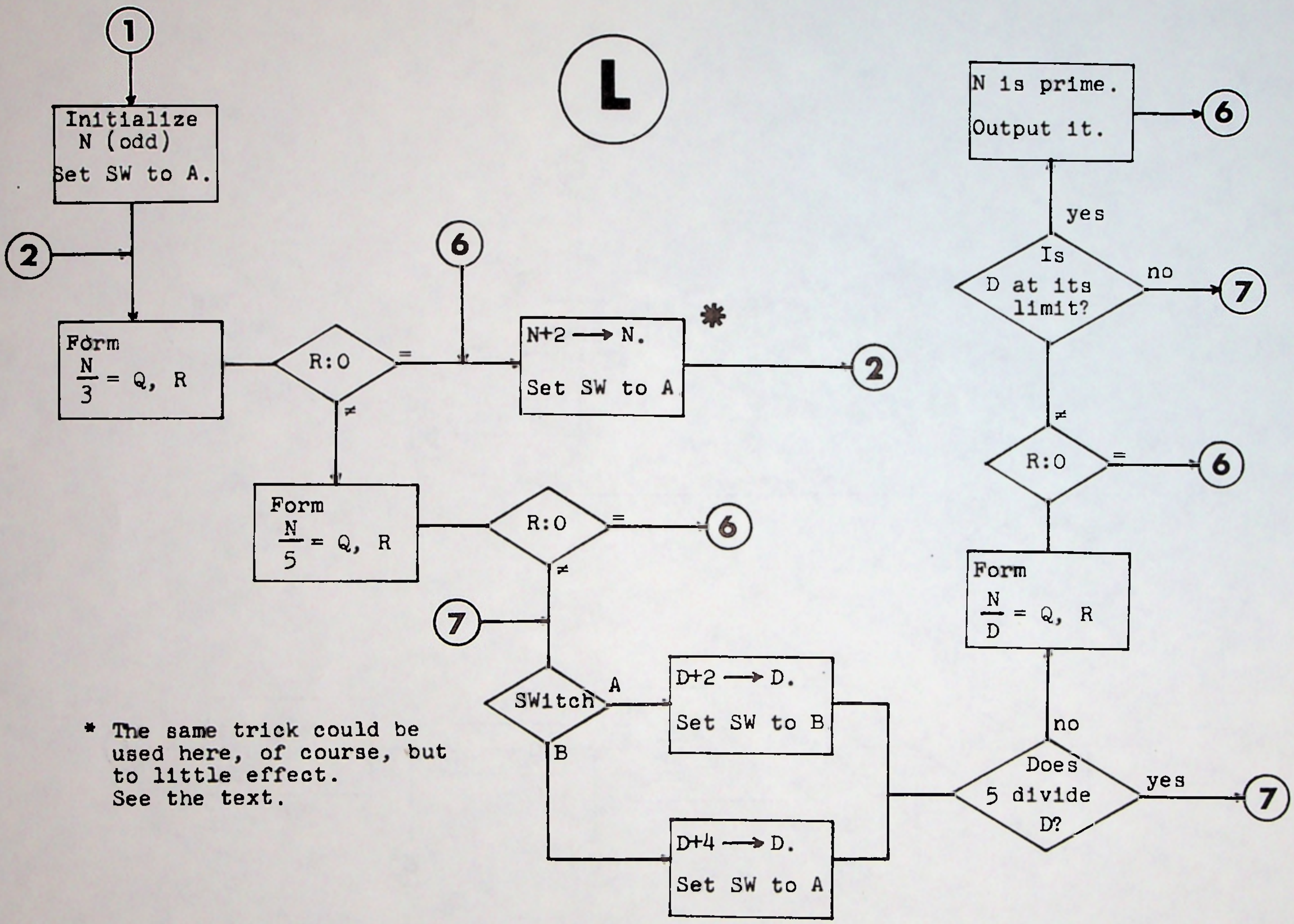
It would appear that I have been making the same blunder for nearly 32 years, which must be some sort of record, or at least an achievement. Fortunately, the blunder produced no wrong results, just a lot of wasted machine time.

The logic of by-passing numbers divisible by 2 and 3 can be extended also to by-pass multiples of 5 by starting with any number of the form D = 30K + 7 and using the difference pattern:

4, 2, 4, 2, 4, 6, 2, 6, 4, 2, 4, 2, 4, 6, 2, 6,...

Thus, to use this scheme on divisors, it is necessary to test for divisibility of N by 2, 3, and 5 separately.


1
Set N to initial (odd) value
2
3 → D
3
Form $\frac{N}{D}$ = Q, R
R:0
=
≠
5
N + 2 → N
2
D^2:N
<
=
>
5
4
D + 2 → D
3
N is prime. Output it.
5
K



* The same trick could be used here, of course, but to little effect. See the text.

Actually, the scheme that was presented in issue 80 was based on having all numbers in the process held in storage in the form of one decimal digit per word. Thus, nothing would be gained in that case by programming an elaborate scheme to by-pass multiples of 5. If multiples of 3 are by-passed, a test for a multiple of 5 can be made most efficiently by simply testing the word containing the unit's digit for 5.

With all this in mind, a better flowchart is given in Figure L.

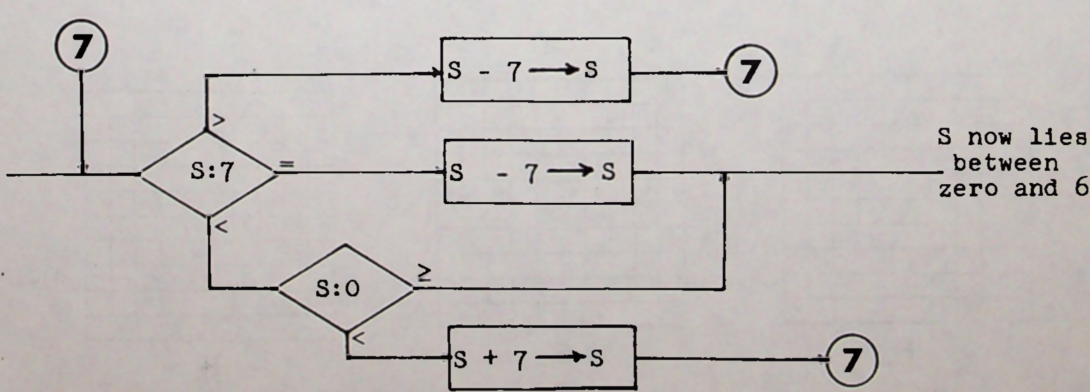
In issue number 79 we published Zeller's congruence for the day of the week:

$$F \equiv \left\{ \left[2.6M - .2\right] + K + D + \left[\frac{D}{4}\right] + \left[\frac{C}{4}\right] - 2C \right\} \bmod 7$$

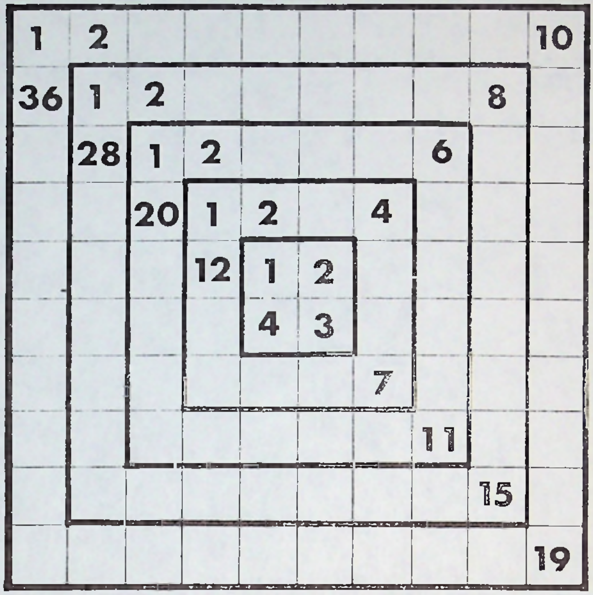
The term [2.6M - .2] is designed to compensate for the various lengths of months. Bob Hall, Arleta, California, suggests that [2.59M] would perform the same function and do it with less computational effort.

It was suggested that, in calculating F, that the sum be initialized to some high multiple of 7, say 77, to avoid going negative on subtracting 2C. This was intended to avoid excessive coding for the case where -2C could possibly carry the sum below zero. It was, of course, a piece of poor computing.

The end result of the formula is to be a <u>positive</u> integer: one of 0, 1, 2, 3, 4, 5, or 6, which is what "mod 7" means. To be neat about it, the sum, S, should be formed just as stated in Zeller's formula, and then the reduction mod 7 (avoiding division, as usual) could be made by this logic:



The Five Square Rings



So you think you understand how random processes will behave?

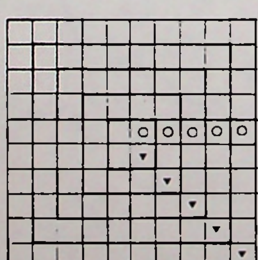
We have here a pattern of five sets of cells arranged as concentric rings of squares. The numbers shown in some of the squares are there only to suggest a scheme for numbering the cells in each of the five sets. Thus, the outer ring might be numbered from one in the upper left corner, clockwise around to 36.

One cell in each ring is to be selected at random. What is the probability that the five cells so selected will lie on a straight line?

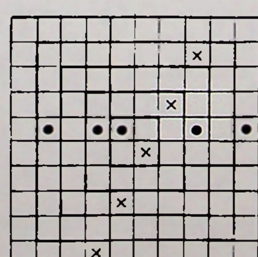
In Figure F there are some simple, straightforward cases. Some other interesting possible cases are also shown, in Figures G and H.

The problem could be attacked analytically, but a Monte Carlo attack would be most interesting, and a challenging coding task.

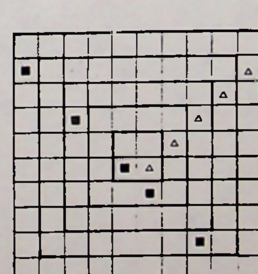
PROBLEM 266



F



G



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